I claim:

1. A method for surface estimation of reservoir properties of a subsurface geologic formation, comprising the steps of:

determining location of and average earth resistivity above, below, and horizontally adjacent to the subsurface geologic formation using geological and geophysical data in the vicinity of the subsurface geologic formation;

Sub. A3

determining dimensions and probing frequency for an electromagnetic source to substantially maximize transmitted vertical and horizontal electric currents at the subsurface geologic formation using the location and the average earth resistivity;

activating the electromagnetic source at or near surface, approximately centered above the subsurface geologic formation;

measuring a plurality of components of electromagnetic response with a receiver array;

determining geometrical and electrical parameter constraints, using the geological and geophysical data; and

processing the electromagnetic response using the geometrical and electrical parameter constraints to produce inverted vertical and horizontal resistivity depth images.

2. The method of claim 1, further comprising the step of:

combining the inverted resistivity depth images with the geological and geophysical data to estimate the reservoir properties.

3. The method of claim 2, wherein the step of determining dimensions and probing frequency is accomplished by numerically solving the uninsulated buried low-frequency electromagnetic antenna problem for the vertical electrical current at the subsurface geologic formation.

4. The method of claim 2, wherein the electromagnetic source comprises:

two continuously grounded circular electrodes positioned at or within the near surface in concentric circles.

5. The method of claim 4, wherein each circular electrode comprises one or more electrically uninsulated conductors.

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6. The method of claim 2, further comprising:

a third circular electrode positioned at or within the near surface and concentric with the two circular electrodes.

7. The method of claim 6, wherein the third circular electrode comprises one or more electrically insulated conductors.

8. The method of claim 2, wherein the electromagnetic source comprises:

six or more grounded linear radial electrodes of equal lengths placed along radii separated by equal angles, whose radial projections intersect at a common central point; and

continuously grounded linear terminating electrodes connected perpendicularly at each end of the grounded electrodes.

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9. The method of claim 8, wherein the length of the terminating electrodes is less than or equal to one tenth of the length of the radial electrodes.

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10. The method of claim 8, wherein the radial electrodes are continuously grounded along their entire length.

11. The method of claim 8, wherein the radial electrodes are continuously grounded only within a distance less than one half of the length of the radial electrode, from each end.

12. The method of claim 2, wherein the subsurface geologic formation is located onshore and wherein the plurality of components of electromagnetic response comprise:

two orthogonal horizontal electric fields;

two orthogonal horizontal magnetic fields; and

a vertical magnetic field.

13. The method of claim 2, wherein the subsurface geologic formation is located offshore and wherein the plurality of components of electromagnetic response comprise:

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two orthogonal horizontal electric fields;

two orthogonal horizontal magnetic fields;

a vertical magnetic field; and

a vertical electric field.

14. The method of claim 2, wherein the receiver array is positioned on a grid.

15. The method of claim 2, wherein the receiver array is positioned as a linear array.

16. The method of claim 2, wherein the receiver array is positioned as a swath array.

17. The method of claim 1, wherein the step of processing the electromagnetic response further comprises the step of:

verifying the average earth resistivities above, below, and horizontally adjacent to the subsurface geologic formation, using the plurality of components of electromagnetic response measured with the receiver array.

18. The method of claim 2, wherein the step of processing the electromagnetic response further comprises the step of:

applying 3-D wave-equation data processing to the electromagnetic response.

19. The method of claim 2, wherein the data processing includes data noise suppression, source deconvolution, and model-guided inversion.

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20. The method of claim 7, wherein the steps of activating the electromagnetic source and measuring the electromagnetic response further comprises the steps of:

measuring a first electromagnetic response without activating the electromagnetic source;

measuring a second electromagnetic response while activating only the third circular insulated electrode; and

measuring a third electromagnetic response while activating only the grounded uninsulated electrodes.

21. The method of claim 20, wherein the step of applying data processing further comprises the steps of:

merging the first and second electromagnetic responses to produce a fourth electromagnetic response;

inverting the first electromagnetic response;

inverting the second electromagnetic response;

inverting the third electromagnetic response;

inverting the fourth electromagnetic response; and

inverting jointly the third and fourth electromagnetic responses.

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